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PL-TR-93-2194

DATABASE RELATIONS FOR SEISMIC PHASES REPORTED BY STATIONS IN THE FORMER SOVIET UNION

Alan L. Kafka

Weston Observatory
Department of Geology and Geophysics
Boston College
Weston, MA 02193

30 September 1993

Scientific Report No. 5

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Directorate of Geophysics
AIR FORCE MATERIEL COMMAND
HANSCOM AIR FORCE BASE, MA 01731-3010

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This technical report has been reviewed and is approved for publication.

JAMES F. LEWKOWICZ
Contract Manager
Solid Earth Geophysics Branch
Earth Sciences Division

JAMES F. LEWKOWICZ
Branch Chief
Solid Earth Geophysics Branch
Earth Sciences Division

DONALD H. ECKHARDT, Director
Earth Sciences Division

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	30 September 1993	Scientific Report No. 5

4. TITLE AND SUBTITLE

Database Relations for Seismic Phases
Reported by Stations in the Former Soviet Union

5. FUNDING NUMBERS

PE 62101F
PR 7600
TA 09
WV AL

Contract F19628-90-K-0035

6. AUTHOR(S)

A.L. Kafka

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Weston Observatory
Department of Geology and Geophysics
Boston College
Weston, MA 02193

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Phillips Laboratory
29 Randolph Rd.
Hanscom AFB, MA 01731-3010
Contract Manager: James Lewkowicz/GPEH

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

PL-TR-93-2194

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13 ABSTRACT (*Maximum 200 words*)

This report is one of five Scientific Reports describing specific research projects conducted at Weston Observatory under Contract No. F19628-90-K-0035. The research conducted under this contract covers a range of topics related to seismology in general and to nuclear test monitoring in particular.

This Scientific Report (No. 5) describes a project in which computer software was developed to produce database relations for seismic phases reported by stations in the former Soviet Union. The programs written for this project read data extracted from computer files of seismic phase data compiled by the International Seismological Centre (ISC) and create database relations containing ISC phase data for a given station. These relations are stored in computer files in the format that is used by the database management system operating at the Center for Seismic Studies. In this report, the programs are described and examples are given to illustrate the type of investigation that can be done once a database has been created for a given set of stations.

14. SUBJECT TERMS

Seismic Phases, Database Relations, Nuclear Explosions

15. NUMBER OF PAGES

64

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

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1. INTRODUCTION

This project addressed one aspect of monitoring nuclear explosions in a given area using a particular set of seismic stations. To evaluate the extent to which a given set of stations can be used to monitor explosions, it is important to know what seismic phases can be observed at those stations from events of a given size and type occurring in the area being monitored. It is possible to obtain a preliminary assessment of what phases could be recorded at a given station by analyzing phases that have actually been reported to the International Seismological Centre (ISC) as part of routine monitoring of earthquakes and explosions. Since there would inevitably be questions regarding the completeness and reliability of phase information provided by station operators in a foreign country, it would be helpful to examine in advance the reporting characteristics of any station that might eventually be used in a treaty verification scenario. This type of information could be useful for estimating how clearly a given seismic phase generated by a nuclear test could be recorded at a given station, if the United States were to monitor that particular station for that specific phase.

Most of the work for this project involved writing computer programs to create database relations for seismic phases reported by stations in the former Soviet Union. These programs, described in this report, read data extracted from the ISC computer files and create database relations containing ISC phase data for a given station. These relations are stored in computer files in the standardized format that is used by the ORACLE database management system (DBMS) operating at the Center for Seismic Studies (CSS, see Anderson et al., 1990).

There are 168 seismic stations in the former Soviet Union that are described in a report by Shishkevish (1974). Of these stations, at least 148 report (or have previously reported) seismic phase data in the ISC bulletins. Figure 1 shows the locations of stations in the former Soviet Union that we have been able to identify as reporting phase data to the ISC, and the names and locations of those stations are listed in Table 1.

The ISC data have been recorded on a CD-ROM, and software is available to extract phase data from that CD-ROM (USGS/NEIC, 1990). The USGS/NEIC program that extracts phase data from the CD-ROM is called FAISE (Fetch Associated Information of Seismic Events). Using the FAISE software and the CD-ROM as a starting point, we extracted phase data reported for specific stations in the former Soviet Union. We have written computer programs to read the output from FAISE, and translate that output into the standardized "external format" that is used by the DBMS operating at the CSS.

2. DATABASE OF SEISMIC PHASES REPORTED FOR STATIONS IN THE FORMER SOVIET UNION

The structure of the database used at the Center for Seismic Studies (CSS) is described by Anderson et al. (1990). The specific database relations that have been created for this project are **arrival, assoc, event and origin**. The information contained in those relations is summarized in Tables 2 - 5. The programs that create these relations from the FAISE output are written in C, and the C code for each program is listed in Appendices A-D of this report. The programs call the functions listed in Appendix E, and require a short file containing input information, also listed in Appendix E.

While the results presented in this report were obtained by running the programs on a Macintosh computer, the C code should be completely portable to other computers. We have successfully run these programs on a DEC-VAX computer operating under the VMS operating system, as well as on several IBM-PC compatible computers operating under the DOS operating system. In all cases, the only changes that were necessary were very minor changes to the C header statements. Since the FAISE program runs in the DOS operating system, the use of these programs on a DOS computer would make it possible to efficiently extract the necessary data for any station and any time period covered by the ISC CD-ROM catalogue. Although these programs were originally intended to be used for stations in the former Soviet Union, they can of course be used to investigate reporting characteristics of stations in any country.

Using the months of January 1984 and January 1986 and the stations OBN and YAK as examples, we illustrate the type of information that is contained in a database created by the programs written for this project. Figure 2 shows all events in the ISC Bulletin (with m_b>0) reported during January 1984 and January 1986. Figure 3 shows the event epicenters corresponding to a "station-phase" catalogue for OBN - January 1986, i.e. all events for which at least one phase was reported by station OBN during January 1986. For comparison with Figure 3, Figure 4 shows epicenters corresponding to the station-phase catalogue for YAK - January 1986. Station OBN only reported phases for events within the former Soviet Union and immediate surrounding areas. YAK, on the other hand, reported phases not only from events within and in the vicinity of the former Soviet Union, but also from events in the western United States, western South America and the southern Atlantic ocean. This difference is at least in part due to the fact that YAK is closer to those particular areas in the Western Hemisphere than OBN, but could also be due to differences in station characteristcs (e.g. lower background noise).

For comparison with these Soviet station-phase catalogues, Figures 5 and 6 show epicenters corresponding to the station-phase catalogues for two United States stations, BLA - January 1986 and GOL - January 1986, respectively. Also for a comparison with the month of January 1986, Figure 7 shows epicenters corresponding to the station-phase catalogue for OBN - January 1984. A more detailed description of the differences in number and type of reported phases at a sample of Soviet and United States stations is given below in Section 3 of this report.

Once the programs for all of the relations have been run for a given station and time period, the data can be read into the DBMS. For the examples described below, we used the ORACLE DBMS operating on a Macintosh computer. The commands for loading the data into the DBMS and creating the necessary tables are written in the Structured Query Language (SQL). Tables 6 and 7 show the results of using SQL queries to extract information about specific phases reported by OBN and YAK for January 1986. The SQL command that generated the results shown in Tables 6 and 7 was:

```
SELECT ARRIVAL.STA, EVNAME, DELTA, MB, QUAL, IPHASE
FROM   ORIGIN, ARRIVAL, ASSOC, EVENT
WHERE ARRIVAL.ARID = ASSOC.ARID
AND ASSOC.ORID = ORIGIN.ORID
AND ORIGIN.EVID = EVENT.EVID;
```

In the next section, we test the software developed for this project by running the programs for several examples involving selected stations in the former Soviet Union, and we compare those results with results for selected stations in the United States. These examples illustrate the type of investigations that can be carried out using the DBMS relations created by the programs.

3. DEMONSTRATION OF DATABASE QUERIES: EXTRACTING PHASE INFORMATION FOR SELECTED STATIONS IN THE SOVIET UNION AND THE UNITED STATES

In this section, we give several examples in which SQL queries are used to extract seismic phase information for specific time periods for selected Soviet stations (OBN, YAK and NVS) and for selected United States stations (BLA, GOL and ALQ). Although the programs written for this project can be run for any time period covered by the ISC data base (i.e. January 1964 through August 1987), we use one-month time segments in these examples because the number of phases reported in a longer period of time can result in quite large output files. For example, information corresponding to 199 phases were reported by ALQ in January 1984 alone. Thus, an entire year

could produce a file containing information on 2,000 or more phases for some stations, and a decade could produce a file containing information on 20,000 or more phases. In routine operation on a relatively large computer, one year time segments are probably quite reasonable to work with, and longer time segments might be appropriate for some applications.

Tables 8 and 9 show the results of executing the same SQL command that generated the results shown in Tables 6 and 7, but in this case for United States stations BLA and GOL, respectively. The computer programs and SQL statements described in this report were tested empirically by comparing the results of running a database search with information listed in the corresponding "hard copy" ISC Bulletin. These tests revealed no obvious errors in any of the programs or SQL statements. As an example of such an empirical test, we chose 50 rows at random from the output shown in Tables 6 through 9 and compared the items in those rows with the corresponding entries in the hard copy Bulletin. Every item chosen in this manner from Tables 6 through 9 was found to be identical to the corresponding entry in the Bulletin.

To illustrate the type of analysis that can be done once the database has been created and loaded into ORACLE, we executed the following SQL query for the month of January 1986 at stations OBN, YAK, NVS, BLA, GOL and ALQ.

```
SELECT IPHASE, COUNT(*)
FROM   ORIGIN, ARRIVAL, ASSOC, EVENT
WHERE ARRIVAL.ARID = ASSOC.ARID
AND ASSOC.ORID = ORIGIN.ORID
AND ORIGIN.EVID = EVENT.EVID;
AND ARRIVAL.STA = ASSOC.STA
GROUP BY IPHASE;
```

The results of executing this command are shown in Table 10, which lists the number of times a given phase was reported during January 1986 at stations OBN, YAK, NVS, BLA, GOL and ALQ. Table 11 shows the same information for the month of January 1984.

Although it is beyond the scope of this report to present a detailed analysis of all the information that could be extracted for the Soviet and United States stations using the database created by these programs, it is helpful to continue our simple example as a way of further illustrating the type of analysis that can be done. Note in Tables 10 and 11 for example, that in both January 1986 and January 1984, all three of the Soviet stations were reporting S phases, while only one S phase (at ALQ in 1984) was reported for all three United States stations. Also, based on these two months, it appears that the phase pP is routinely reported by OBN and YAK in

the former Soviet Union, and by GOL and ALQ in the United States However, for some reason pP is not reported by NVS and BLA. It is also interesting to note in Tables 10 and 11 that the ratio of reported PKP phases to reported P phases is fairly consistent for a given station.

While the pattern of reporting from the Soviet stations is quite uniform for both months and all three stations, the pattern is not uniform from one United States station to the next. Station ALQ reported many more phases than GOL, and BLA reported less phases than any of the other United States or Soviet stations. The DBMS can be used to investigate what might be the cause(s) of such differences. For example, Table 12 shows the results of executing the following SQL command for the GOL - January 1984 station-phase data base:

```
SELECT ARRIVAL.STA, IPHASE, EVNAME, DELTA, MB, LAT, LON
FROM   ORIGIN, ARRIVAL, ASSOC, EVENT
WHERE ARRIVAL.ARID = ASSOC.ARID
AND ASSOC.ORID = ORIGIN.ORID
AND ORIGIN.EVID = EVENT.EVID;
AND ARRIVAL.STA = ASSOC.STA
AND IPHASE = 'P'
ORDER BY DELTA;
```

Executing that same SQL command for the ALQ - January 1984 station-phase data base, and comparing the output with that shown for GOL in Table 12, we found that about half of the difference between the outputs for GOL and ALQ can be explained by the fact that ALQ reported many more foreshocks and aftershocks of a given event than GOL did.

As a final illustration, we compare the reported P phases for NVS versus OBN for January 1984. This was accomplished by executing the previous SQL command (i.e. corresponding to the discussion of Table 12) for both stations, and comparing the output. The results are illustrated in Figure 8, which shows events for which P waves were reported by NVS, but not by OBN (Figure 8a), and the same information for OBN (Figure 8b). While one might have expected that the events "seen" by NVS and not by OBN would be located in very different areas than the events seen by OBN and not by NVS, it is interesting to note that the geographical distribution of epicenters in Figure 8a is quite similar to that in Figure 8b. This suggests that, for the most part, the phases of the events missed by NVS but reported by OBN could actually be found on the NVS seismograms (and vice versa). Since this conclusion is based on geographical distribution alone, we could continue this analysis by using the DBMS to search for other event parameters (such as mb, ms and ml) to investigate why phases reported by one station were not reported by the other.

4. CONCLUDING REMARKS

While the original intent of this project was to develop a data base of seismic phases reported by stations in the former Soviet Union, the programs written for this project can be used for any station that reports to the ISC. This makes it possible to obtain a preliminary assessment of what phases could be recorded at a given station in any part of the world by analyzing phases that have actually been reported as part of routine seismic monitoring.

The programs used to produce the relations for this data base are available from the author, either in the form of C code (in ASCII format) written on an IBM-PC file, or (preferably) by electronic mail. Anyone interested in obtaining copies of these programs should contact the author at the address on the cover page of this report or at KAFKA@BCVMS.BC.EDU.

5. ACKNOWLEDGEMENTS

Thanks to Mary Ann Brennan of the Center for Seismic Studies for providing me with the CSS functions for time conversion (timecon.c and dtoepoch.c), and also for her assistance in integrating those functions into my programs.

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Table 1

Stations in the Former Soviet Union that Report,
or Have Previously Reported, Seismic Phase Data to the ISC

(Locations and precision of locations are from Shishkevish, 1974.)

Station Name	Code	Latitude,	Longitude	Region
Abastumani	ABS	41°45'N,	42°50'E	Caucasus
Agalyk	AGL	39.9°N,	66.9°E	Central Asia
Akhalkalaki	AKH	41°24'N,	43°29'E	Caucasus
Alla	ALL	54°42'N,	110°46'E	Baykal
Alma-Ata	AAA	43°16'N,	76°57'E	Central Asia
Alushta	ALU	44°42'N,	34°25'E	Crimea
Andizhan	ANR	40°45'N,	72°22'E	Central Asia
Apakhonchich	APN	~56.0°N,	~160.9°E	Far East
Apatity	APA	67°33'N,	33°20'E	Arctic
Aral	ARLS	~41.4°N,	~73.9°E	Central Asia
Arshan	ARS	51°55'N,	102°30'E	Baykal
Ashkhabad	ASH	37°57'N,	58°21'E	Kopet Dag
Avacha	AVH	53°04'N,	158°30'E	Far East
Baku	BAK	40°23'N,	49°54'E	Caucasus
Bakuriani	BKR	41°44'N,	43°31'E	Caucasus
Barguzin	BGZ	53°37'N,	109°37'E	Baykal
Bodaybo	BOD	57°51'N,	114°11'E	Baykal
Bodon	BDN	53°43'N,	110°06'E	Baykal
Bogdanovka	BGD	41°16'N,	43°36'E	Caucasus
Bogi-Zagon	BZN	~38.5°N,	~69.8°E	Central Asia
Chagan-Uzun	CUR	50°06'N,	88°21'E	Altay-Sayan
Chagda	CGD	58°45'N,	130°37'E	Yakutiya
Chara	CRS	56°54'N,	118°12'E	Baykal
Chilik	CHL	43°34'N,	78°25'E	Central Asia
Chimkent	CHM	42°19'N,	69°36'E	Central Asia
Chul'man	CLNS	~56.9°N,	~125°E	Yakutiya
Chuyan-Garon	CGT	38°39'N,	69°10'E	Central Asia
Dushanbe	DSH	38°34'N,	68°46'E	Central Asia
Dusherti	DUS	42°05'N,	44°42'E	Caucasus
Dzherino	DZE	~38.7°N,	~68.5°E	Central Asia
Dzhirgatal'	DZT	39°13'N,	71°14'E	Central Asia
Dzhizak	DZI	40.1°N,	67.8°E	Central Asia
El'tsovka	ELT	53°15'N,	86°16'E	Altay-Sayan
Erevan	ERE	40°11'N,	44°30'E	Caucasus
Erzin	ERNS	50°15'N,	95°10'E	Altay-Sayan
Esso	ESO	55°56'N,	158°42'E	Far East
Fabrichnaya	FAB	43°08'N,	76°26'E	Central Asia
Feodosiya	FED	45°01'N,	36°23'E	Crimea
Fergana	FRG	40°23'N,	71°47'E	Central Asia
Frunze	FRU	42°50'N,	74°37'E	Central Asia
Garm	GAM, GAR	39°00'N,	70°19'E	Central Asia
Gegechkori	GEG	42°21'N,	42°23'E	Caucasus
Gori	GOR	41°59'N,	44°07'E	Caucasus
Goris	GRS	39°30'N,	46°20'E	Caucasus
Groznyy	GRO	43°19'N,	45°42'E	Caucasus

Table 1 (Continued)

Irkutsk	IRK	52°16'N,	104°19'E	Baykal
Iul'tin	ILT	67°50'N,	178°48'W	Arctic
Kabansk	KAB	52°03'N,	106°39'E	Baykal
Kalaydasht	KLD	~38.6°N,	~69.5°E	Central Asia
Kara-Su	KRU	38°29'N,	68°59'E	Central Asia
Khaishi	KHS	42°57'N,	42°12'E	Caucasus
Khandyga	KHG	62°40'N,	135°36'E	Yakutiya
Khapcheranga	KPC	49°42'N,	112°24'E	Baykal
Kheys	KHE	80°37'N,	58°03'E	Arctic
Khorog	KHO	37°29'N,	71°32'E	Central Asia
Kirovabad	KRV	40°39'N,	46°20'E	Caucasus
Kishinev	KIS	47°01'N,	28°52'E	Carpathia
Kizyl-Arvat	KAT	39°12'N,	56°16'E	Kopet Dag
Klyuchi	KLY	56°19'N,	160°52'E	Far East
Kosov	KSV	48°19'N,	25°04'E	Carpathia
Kozyrevsk	KOZ	56°04'N,	159°52'E	Far East
Krasnovodsk	KRS	40°00'N,	53°00'E	Kopet Dag
Kronoki	KRN	42°36'N,	161°10'E	Far East
Krutoberegovo	KBG	56°15'N,	162°42'E	Far East
Kulyab	KUL	37°54'N,	69°45'E	Central Asia
Kumora	KMO	55°53'N,	111°13'E	Baykal
Kuril'sk	KUR	45°14'N,	147°52'E	Far East
Kurmenty	KRM	43°00'N,	78°27'E	Central Asia
Kyakhta	KYA	50°22'N,	106°27'E	Baykal
Lagodekhi	LGD	41°49'N,	46°16'E	Caucasus
Leninakan	LEN	40°41'N,	43°51'E	Caucasus
Lenkoran'	LNK	38°46'N,	48°50'E	Caucasus
L'vov	LVV	49°49'N,	24°02'E	Carpathia
Lyangar	LNA	~38.2°N,	~69.2°E	Central Asia
Magadan	MAG	59°33'N,	150°48'E	Northeast
Makhachkala	MAK	43°01'N,	47°26'E	Caucasus
Malo-Kuril'sk	MLK	43°52'N,	146°49'E	Far East
Matua	MAU	48°05'N,	153°13'E	Far East
Mezhgor'ye	MEZ	48°31'N,	23°31'E	Carpathia
Mingechaur	MGC	40°45'N,	47°03'E	Caucasus
Mondy	MOY	51°41'N,	100°59'E	Baykal
Moskva	MOS	55°44'N,	37°38'E	Teleseismic
Murgab	MUR	38°22'N,	73°56'E	Central Asia
Mys Shipunskiy	SPN	~53.1°N,	~160.0°E	Far East
Nakhichevan'	NAK	39°12'N,	45°24'E	Caucasus
Namangan	NAM	40°59'N,	71°40'E	Central Asia
Naryn	NRN	41°26'N,	76°00'E	Central Asia
Nelyaty	NLY	56°29'N,	115°41'E	Baykal
Nizhneangarsk	NIZ	55°47'N,	109°33'E	Baykal
Novosibirsk	NVS	55°02'N,	82°55'E	Altay-Sayan
Nurata	NUT	40°33'N,	65°41'E	Central Asia
Obi-Garm	OBG	38°43'N,	69°43'E	Central Asia
Obninsk	OBN	55°10'N,	36°27'E	Teleseismic
Okha	OKH	53°33'N,	142°56'E	Sakhalin
Omsukchan	OMS	62°32'N,	155°48'E	Northeast
Oni	ONI	42°35'N,	43°26'E	Caucasus
Orlik	ORL	52°30'N,	99°55'E	Baykal

Table 1 (Continued)

Pauzhetka	PAU	~51.5°N,	~156.8°E	Far East
Petropavlovsk	PET	53°00'N,	158°38'E	Far East
Przheval'sk	PRZ	42°29'N,	78°24'E	Central Asia
Pulkovo	PUL	59°46'N,	30°19'E	Teleseismic
Pyatigorsk	PYA	44°02'N,	43°04'E	Caucasus
Rakhov	RAK	47°57'N,	24°10'E	Carpathia
Regar	RGR	38°30'N,	68°14'E	Central Asia
Reydovo	REI	45°16'N,	148°02'E	Far East
Rybach'ye	RYB	42°08'N,	77°10'E	Central Asia
Saberio	SAB	42°39'N,	41°54'E	Caucasus
Samarkand	SAM	39°40'N,	66°59'E	Central Asia
Semipalatinsk	SEM	50°24'N,	80°15'E	Teleseismic
Semlyachik	SEL	54°07'N,	160°11'E	Far East
Severo-Kuril'sk	SKR	50°40'N,	156°06'E	Far East
Seymchan	SEY	62°53'N,	152°26'E	Northeast
Shaartuz	SHTZ	37°16'N,	68°08'E	Central Asia
Shemakha	SHE	40°38'N,	48°38'E	Caucasus
Simferopol'	SIM	44°57'N,	34°07'E	Crimea
Simushir	SIU	46°51'N,	151°42'E	Far East
Sochi	SOC	43°35'N,	39°43'E	Caucasus
Sredniy Kalar	SRK	55°52'N,	117°22'E	Baykal
Stepanavan	STE	41°00'N,	44°23'E	Caucasus
Susuman	SUUS	62°47'N,	148°10'E	Northeast
Sverdlovsk	SVE	56°48'N,	60°38'E	Teleseismic
Talgar	TLG	43°14'N,	77°14'E	Central Asia
Tamdybulak	TMD	41.6°N,	64.6°E	Central Asia
Tashkent	TAS	41°20'N,	69°18'E	Central Asia
Tiksi	TIK	71°38'N,	128°52'E	Arctic
Topolovo	TOP	~53.3°N,	~158.4°E	Far East
Tsebel'da	TSE	43°01'N,	41°17'E	Caucasus
Tupik	TUP	54°26'N,	119°54'E	Baykal
Tymovskoye	TYV	50°51'N,	142°39'E	Far East
Tyrgan	TRG	52°45'N,	106°20'E	Baykal
Uakit	UKT	55°30'N,	113°37'E	Baykal
Uglegorsk	UGL	49°05'N,	142°04'E	Far East
Ust'-Elegest	UER	51°34'N,	94°05'E	Altay-Sayan
Ust'-Kan	UKR	50°57'N,	84°45'E	Altay-Sayan
Ust'-Nera	UNR	64°34'N,	143°12'E	Yakutiya
Ust'-Nyukzha	USZ	56°34'N,	121°37'E	Yakutiya
Ust'-Omchug	USO	61°09'N,	149°38'E	Northeast
Uzhgorod	UZH	48°38'N,	22°18'E	Carpathia
Vannovskaya	VAN	37°57'N,	58°06'E	Kopet Dag
Vardenis	VRD	40°11'N,	45°43'E	Caucasus
Vladivostok	VLA	43°07'N,	131°54'E	Teleseismic
Yakutsk	YAK	62°01'N,	129°43'E	Yakutiya
Yalta	YAL	44°30'N,	34°10'E	Crimea
Yuzhno-Kuril'sk	YUK	44°02'N,	145°51'E	Far East
Yuzhno-Sakhalinsk	YSS	47°01'N,	142°43'E	Far East
Zakamensk	ZAK	50°23'N,	103°17'E	Baykal
Zhiloy ostrov	ZHI	40°19'N,	50°36'E	Caucasus
Zugdidi	ZUG	42°31'N,	41°53'E	Caucasus

Table 2

(Summarized from Anderson et al., 1990)

Relation: **arrival** (summary information on a seismic arrival).

Attribute	External Format	Character Positions	Description
sta	a6	1-6	station code
time	f17.5	8-24	epoch time
arid	i8	26-33	arrival id
jdate	i8	35-42	julian date
stassid	i8	44-51	stassoc id
chanid	i8	53-60	instrument id
chan	a8	62-69	channel code
iphase	a8	71-78	reported phase
stype	a1	80-80	signal type
deltim	f6.3	82-87	delta time
azimuth	f7.2	89-95	observed azimuth
delaz	f7.2	97-103	delta azimuth
slow	f7.2	105-111	observed slowness
delslo	f7.2	113-119	delta slowness
ema	f7.2	121-127	emergence angle
rect	f7.3	129-135	rectilinearity
amp	f10.1	137-146	amplitude
per	f7.2	148-154	period
logat	f7.2	156-162	log(amp/per)
clip	a1	164-164	clipped flag
fm	a2	166-167	first motion
snr	f10.2	169-178	signal to noise ratio
qual	a1	180-180	signal onset quality
auth	a15	182-196	source/originator
commid	i8	198-205	comment id
lddate	a17	207-223	load date

Table 3

(Summarized from Anderson et al., 1990)

Relation: assoc (data associating arrivals with origins).

Attribute	External Format	Character Positions	Description
arid	i8	1-8	arrival id
orid	i8	10-17	origin id
sta	a6	19-24	station code
phase	a8	26-33	associated phase
belief	f4.1*	35-38	phase confidence
delta	f8.3	40-47	station to event distance
seaz	f7.2	49-55	station to event azimuth
esaz	f7.2	57-63	event to station azimuth
timeres	f8.3	65-72	time residual
timedef	a1	74-74	time = defining, non-defining
azres	f7.1	76-82	azimuth residual
azdef	a1	84-84	azimuth = defining, non-defining
slores	f7.0**	86-92	slowness residual
slodef	a1	94-94	slowness = defining, non-defining
emares	f7.1	96-102	incidence angle residual
wgt	f6.3	104-109	location weight
vmodel	a15	111-125	velocity model
commid	i8	127-134	comment id
lddate	a17	load date	load date

* The format for this attribute was given as f4.2 in Anderson et al. (1990), but f4.1 is used here because it appears to be the format that was intended to be used for this attribute.

** The format for this attribute was given as f7.2 in Anderson et al. (1990), but f7.0 is used here because it appears to be the format that was intended to be used for this attribute.

Table 4

(Summarized from Anderson et al., 1990)

Relation: **event** (event identification).

Attribute	External Format	Character Positions	Description
evid	i8	1-8	event id
evname	a15	10-24	event name
prefor	i4	26-33	preferred origin
auth	a15	35-49	source/originator
commid	i8	51-58	comment id
lddate	a17	136-152	load date

Table 5

(Summarized from Anderson et al., 1990)

Relation: **origin** (data on event location and confidence bounds).

Attribute	External Format	Character Positions	Description
lat	f9.4	1-9	estimated latitude
lon	f9.4	11-19	estimated longitude
depth	f9.4	21-29	estimated depth
time	f17.5	31-47	epoch time
orid	i8	49-56	origin id
evid	i8	58-65	event id
jdate	i8	67-74	julian date
nass	i4	76-79	number of associated phases
ndef	i4	81-84	number of locating phases
ndp	i4	86-89	number of depth phases
grn	i8	91-98	geographic region number
srn	i8	100-107	seismic region number
etype	a7	109-115	event type
depdp	f9.4	117-125	estimated depth from depth phases
dtype	a1	127-127	depth method used
mb	f7.2	129-135	body wave magnitude
mbid	i8	137-144	mb magid
ms	f7.2	146-152	surface wave magnitude
msid	i8	154-161	ms magid
ml	f7.2	163-169	local magnitude
mlid	i8	171-178	ml magid
algorithm	a15	180-194	location algorithm used
auth	a15	196-210	source/originator
commid	i8	212-219	comment id
lddate	a17	221-237	load date

Table 6

STA	EVNAME	DELTA	MB	Q	IPHASE
OBN	198601 1 6 9 63	16.42	4.8	e	P
OBN	198601 12210261	61.55	5.1	e	P
OBN	198601 3 943273	90.97	5.4	e	P
OBN	198601 3 943273	90.97	5.4	i	S
OBN	198601 31558 94	62.94	5	e	P
OBN	198601 31558 94	62.94	5	e	S
OBN	198601 4 952537	127.31	5		PKP
OBN	198601 41336337	127.31	5.3		PKP
OBN	198601 5 2 7362	127.34	4.7	e	PKP
OBN	198601 5 921310	65.47	5		P
OBN	198601 5 921310	65.47	5	e	pP
OBN	198601 6 0 9 95	16.74	4.8	e	P
OBN	198601 6 0 9 95	16.74	4.8	i	S
OBN	198601 61737201	35.77	4.9		P
OBN	198601 71312 84	89.2	5	e	P
OBN	198601 71355 16	71.25	4.9	e	P
OBN	198601 71355 16	71.25	4.9	e	pP
OBN	198601 8 027207	18.68	4.2	e	P
OBN	198601 8 027207	18.68	4.2	e	S
OBN	19860110 346309	44.35	5.5		P
OBN	19860110 346309	44.35	5.5	e	pP
OBN	19860110 346309	44.35	5.5	e	S
OBN	19860110 6 2585	75.19	4.9	e	P
OBN	1986011115 1 75	18.63	4.3	e	P
OBN	198601122014557	31	5.4		P
OBN	198601122014557	31	5.4	e	S
OBN	198601131157193	69.52	5.2	e	P
OBN	198601131348 36	17.88	4.8		P
OBN	19860114 3 3373	30.05	5.2		P
OBN	19860114 3 3373	30.05	5.2	e	S
OBN	19860116 5 8347	84.86	5.5		P
OBN	19860116 5 8347	84.86	5.5	e	pP
OBN	19860116 5 8347	84.86	5.5	e	S
OBN	19860116 834447	72.52	5.1		P
OBN	198601161111599	74.94	5.1	e	P
OBN	1986011613 4312	67.5	5.4		P
OBN	1986011613 4312	67.5	5.4	e	sP
OBN	1986011613 4312	67.5	5.4	e	S
OBN	19860117 753454	85.15	4.8		P
OBN	19860118 744487	55.29	5.2		P
OBN	19860118 744487	55.29	5.2	e	sP
OBN	19860118 756240	125.39	5.1		PKP
OBN	19860119 635510	76.99	5.2		P
OBN	198601191445465	34.11	5	e	P
OBN	19860122 2 1156	32.74	4.4		P
OBN	19860122 758399	29.24	4.2	e	P
OBN	198601221226458	117.56	5.9	e	PKP
OBN	198601221457132	89.07	5.6		P
OBN	198601221457132	89.07	5.6	e	pP
OBN	19860123 816 46	63.19	4.9	e	P
OBN	1986012516 0415	28.86	5.1	e	P
OBN	19860127 243575	69.55	4.9	e	P
OBN	19860127 719343	21.91	4.6	e	P
OBN	198601271635514	18.16	5.3		P

Table 6 (Continued)

OBN	198601271635514	18.16	5.3	e	S
OBN	198601281232168	64.62	5.7		P
OBN	198601281232168	64.62	5.7	e	S
OBN	19860129 927419	89.55	5.3		P
OBN	198601311748 42	64.63	5.1		P
OBN	198601311748 42	64.63	5.1	e	sP

60 records selected.

Table 7

STA	EVNAME	DELTA	MB	Q	IPHASE
YAK	198601161545 67	48.68	5.3	i	pP
YAK	198601161545 67	48.68	5.3	i	S
YAK	198601161853 50	34.72	4.8		P
YAK	19860117 753454	58.76	4.8		P
YAK	19860118 158589	31.97	5.8		P
YAK	19860118 158589	31.97	5.8	i	S
YAK	19860118 158589	31.97	5.8	i	sS
YAK	19860118 744487	47.15	5.2		P
YAK	19860118 756240	82.76	5.1		P
YAK	19860119 635510	36.18	5.2		P
YAK	19860119 635510	36.18	5.2	i	S
YAK	198601191445465	49.08	5		P
YAK	198601192225571	31.57	4.8	e	P
YAK	198601201928226	37.45	4.5		P
YAK	1986012022 1161	37.49	4.7		P
YAK	19860122 2 1156	51.41	4.4	e	P
YAK	198601221226458	75.97	5.9		P
YAK	198601221226458	75.97	5.9	i	sP
YAK	19860114 3 3373	44.07	5.2	i	pP
YAK	19860114 3 3373	44.07	5.2	i	sP
YAK	19860114 3 3373	44.07	5.2	i	S
YAK	198601141157492	37.47	5.1		P
YAK	198601141856299	37.47	5.1		P
YAK	1986011419 5 54	37.45	5.1		P
YAK	198601151730273	37.47	4.8		P
YAK	198601152017312	89.17	6		P
YAK	198601152017312	89.17	6	e	S
YAK	19860116 5 8347	56	5.5		P
YAK	19860116 5 8347	56	5.5	i	SP
YAK	19860116 834447	32.75	5.1	e	P
YAK	19860116 834447	32.75	5.1	i	S
YAK	198601161111599	34.67	5.1		P
YAK	1986011613 4312	37.6	5.4		P
YAK	1986011613 4312	37.6	5.4	e	S
YAK	1986011613 4312	37.6	5.4	i	ScP
YAK	198601161545 67	48.68	5.3		P
YAK	198601 92141551	21.41	4.5		P
YAK	198601 92141551	21.41	4.5	i	sP
YAK	198601 92141551	21.41	4.5	i	S
YAK	19860110 346309	43.69	5.5		P
YAK	19860110 346309	43.69	5.5	i	S
YAK	19860110 6 2585	34.95	4.9		P
YAK	198601111231146	80.93	5.2		P
YAK	198601111350137	69	5.1		P
YAK	198601111350137	69	5.1	i	S
YAK	198601122014557	46.52	5.4		P
YAK	198601122014557	46.52	5.4	i	S
YAK	198601122343182	19.61	5		P
YAK	198601122343182	19.61	5	i	S
YAK	19860113 842250	37.48	4.8		P
YAK	198601131157193	38.72	5.2	e	P
YAK	198601131742414	69.28	5		P
YAK	198601132322399	63.48	5		P

Table 7 (Continued)

YAK	19860114 3 3373	44.07	5.2		P
YAK	198601 12210261	18.91	5.1		P
YAK	198601 3 224398	145.61	5.2		PKP
YAK	198601 3 943273	62.87	5.4		P
YAK	198601 3 943273	62.87	5.4	i	S
YAK	198601 31558 94	57.47	5		P
YAK	198601 31558 94	57.47	5	i	pP
YAK	198601 31558 94	57.47	5	i	S
YAK	198601 4 952537	84.86	5		P
YAK	198601 41336337	84.84	5.3		P
YAK	198601 5 2 7362	84.95	4.7		P
YAK	198601 5 553521	67.44	5.8		P
YAK	198601 5 921310	21.41	5		P
YAK	198601 5 921310	21.41	5	i	S
YAK	198601 7 8 8466	84.66	5		P
YAK	198601 71038546	92.56	5.2		P
YAK	198601 71038546	92.56	5.2	i	pP
YAK	198601 71355 16	65.57	4.9		P
YAK	198601 9 624425	17.59	4.9	e	P
YAK	198601221226458	75.97	5.9	i	S
YAK	198601221457132	62.43	5.6		P
YAK	198601221457132	62.43	5.6	i	S
YAK	198601221732540	50.4	5.1		P
YAK	19860123 816 46	19.03	4.9		P
YAK	19860123 816 46	19.03	4.9	i	S
YAK	198601231353562	19.25	4.8		P
YAK	198601231353562	19.25	4.8	e	S
YAK	1986012516 0415	35.65	5.1		P
YAK	1986012516 0415	35.65	5.1	i	sS
YAK	19860126 748218	142.41	5.7		PKP
YAK	198601261628554	34.51	4.7	e	P
YAK	198601261628554	34.51	4.7	e	pP
YAK	198601261729528	91.99	5	e	P
YAK	198601261920511	66.26	5.2		P
YAK	19860127 243575	38.73	4.9		P
YAK	19860127 349431	27.42	4.8		P
YAK	19860127 349431	27.42	4.8	i	S
YAK	19860127 349431	27.42	4.8	i	sS
YAK	19860127 735238	76.22	5.5		P
YAK	19860127 735238	76.22	5.5	i	S
YAK	198601271635514	52.47	5.3	e	P
YAK	198601271635514	52.47	5.3	i	S
YAK	198601272032 26	38.21	4.7		P
YAK	19860128 928232	39.29	4.7	e	P
YAK	198601281232168	59.14	5.7		P
YAK	198601281232168	59.14	5.7	i	S
YAK	1986012818 5236	34.26	4.8	e	P
YAK	1986012818 5236	34.26	4.8	e	sS
YAK	1986012820 1287	79.59	4.9		P
YAK	19860129 927419	49.46	5.3		P
YAK	19860129 927419	49.46	5.3	i	S
YAK	19860130 715330	58.01	5.1		P
YAK	19860131 227 32	20.8	4.9	e	P
YAK	198601311437234	153.7	5.1		PKP
YAK	198601311748 42	21.33	5.1		P

Table 7 (Continued)

YAK	198601311748 42	21.33	5.1	e	sP
YAK	198601311748 42	21.33	5.1	i	S

110 records selected.

Table 8

STA	EVNAME	DELTA	MB	Q	IPHASE
BLA	198601 8 342511	73.03	5.2	e	P
BLA	19860112 638220	41	5.5		P
BLA	19860114 3 9357	32.55	5.2	e	P
BLA	198601141034 21	121.42	5.6		PKP
BLA	19860126 748218	64.52	5.7		P
BLA	198601261920511	32.49	5.2	e	P
BLA	198601291334100	30.4	5.5		P
BLA	198601302226347	30.34	4.9		P
BLA	198601302323289	30.32	4.8		P
BLA	198601311646410	4.41	4.8	e	Pn

10 records selected.

Table 9

STA	EVNAME	DELTA	MB	Q	IPHASE
GOL	19860130 6 6408	25.4	4.5	e	P
GOL	19860130 715330	16.94	5.1	e	P
GOL	198601301641 10	91.91	4.7	e	P
GOL	198601302226347	41.61	4.9	e	P
GOL	198601302323289	41.6	4.8	e	P
GOL	19860131 551406	69.24	4.9	e	P
GOL	19860131 551406	69.24	4.9	e	pP
GOL	198601311646410	18.48	4.8	e	P
GOL	198601311748 42	77.61	5.1	e	P
GOL	198601261920511	12.87	5.2	e	P
GOL	19860127 052374	27.19	4.4	e	P
GOL	19860127 159421	85.17	4.7	e	P
GOL	19860127 349431	53.99	4.8	e	P
GOL	19860127 735238	99.22	5.5	e	P
GOL	198601271021599	91.97	5.2	e	P
GOL	198601271936177	21.67	4.6	e	P
GOL	19860128 651466	48.61	5.2	e	P
GOL	198601281232168	128.49	5.7	e	PKP
GOL	198601281543573	21.77	4.7	i	P
GOL	198601282319 51	85.82	5	e	P
GOL	198601282319 51	85.82	5	e	
GOL	19860129 927419	94.74	5.3		P
GOL	198601291019 52	40.79	4.7	e	P
GOL	198601291334100	41.6	5.5	e	P
GOL	198601291349429	41.58	4.7		P
GOL	198601291447175	41.52	4.7	e	P
GOL	1986012920 1279	22.36	4.6		P
GOL	19860117 415 00	56.02	5.5	e	P
GOL	19860118 158589	47.2	5.8	e	P
GOL	19860119 635510	88.21	5.2	e	P
GOL	19860119 8 3287	45.3	4.9	e	P
GOL	198601191128 14	26.82	4.2	e	P
GOL	19860121 524231	88.53	5.6	e	P
GOL	198601211739490	84.31	4.6	e	P
GOL	198601211739490	84.31	4.6	e	
GOL	1986012212 9562	25.24	4.1	e	P
GOL	198601221226458	99.18	5.9	e	P
GOL	198601221457132	120.24	5.6	i	PKP
GOL	19860125 449417	88.58	5	e	P
GOL	19860125 939465	50.62	5.2	e	P
GOL	198601252023183	148.37	4.8	e	PKP
GOL	198601252023183	148.37	4.8	e	sPKP2
GOL	19860126 748218	73.76	5.7	i	P
GOL	19860126 748218	73.76	5.7	e	sP
GOL	198601 1 437249	25.13	4.6	e	P
GOL	198601 122 1182	20.43	5.2	e	P
GOL	198601 21435598	21.14	4.8	e	P
GOL	198601 22042403	144.41	4.8	e	PKP
GOL	198601 22133425	149.78	4.8	e	PKP
GOL	198601 3 943273	118.86	5.4	e	PKP
GOL	198601 42331 77	20.42	5.1		P
GOL	198601 71038546	91.22	5.2	e	P
GOL	198601 71225139	25.09	4.3	e	P
GOL	198601 8 342511	81.37	5.2	e	P

Table 9 (Continued)

GOL	19860112 638220	49.62	5.5	e	P
GOL	198601121651325	21.34	4.7	e	P
GOL	198601131232 46	5.2	0	e	Pn
GOL	19860116 834447	88.76	5.1	e	P
GOL	1986011614 0 77	43.66	4.8		P
GOL	1986011623 7355	88.99	5		P

61 records selected.

Table 10

Phases Reported by Selected Stations in January 1986

Phase	OBN	YAK	NVS	BLA	GOL	ALO
P	36	63	29	8	49	129
PKP	5	3	2	1	6	22
P/PKP ratio	0.14	0.05	0.07	0.13	0.12	0.17
PcP	0	0	0	0	0	2
PcS	0	0	1	0	0	0
Pdiff	0	0	1	0	0	0
Pn	0	0	0	1	1	3
pP	5	5	0	0	1	8
pPKP	0	0	0	0	0	0
S	11	25	16	0	0	0
ScP	0	1	0	0	0	0
ScS	0	0	0	0	0	0
SKS	0	0	0	0	0	0
SP	0	1	1	0	0	0
sP	3	4	0	0	1	0
sPKP2	0	0	0	0	1	0
sS	0	3	0	0	0	0
Unidentified	0	0	0	0	2	0

Table 11

Phases Reported by Selected Stations in January 1984

Phase	OBN	YAK	NVS	BLA	GOL	ALO
P	63	93	62	12	35	126
PKP	7	7	4	2	4	50
P/PKP ratio	0.11	0.08	0.06	0.17	0.11	0.40
PcP	0	0	0	0	0	1
Pdiff	0	0	0	0	1	1
PcS	0	0	0	0	0	0
Pn	0	0	0	0	0	0
pP	7	9	0	0	4	14
pPKP	0	0	0	0		1
S	12	38	35	0	0	1
ScP	0	0	0	0	0	1
ScS	0	1	0	0	0	0
SKS	1	0	0	0	0	0
SP	0	0	0	0	0	0
sP	4	2	1	1	1	3
sPKP2	0	0	0	0	0	0
sS	1	2	0	0	0	0
Unidentified	0	0	0	0	3	1

Table 12

STA	IPHASE	EVNAME	DELTA	MB	LAT	LON
GOL	P	198401281923284	22.76	5	17.3205	-100.12
GOL	P	1984013018 1 44	35.8	4.8	55.7564	-154.3546
GOL	P	198401282252446	35.88	4.9	9.2516	-83.8755
GOL	P	19840123 559460	38.85	4.9	20.2941	-65.9484
GOL	P	198401111135537	42.55	5	-3.0036	-103.0225
GOL	P	1984012817 4392	43.01	5	6.6627	-74.5211
GOL	P	198401 61137498	43.79	5	6.7488	-73.0643
GOL	P	19840117 417173	44.01	4.5	5.8248	-73.9573
GOL	P	1984012322 6 64	44.79	5.4	53.2611	-169.6661
GOL	P	198401171619 46	48.68	5.9	-3.9152	-81.4104
GOL	P	19840113 229 20	49.93	5.8	-3.8823	-78.4707
GOL	P	198401 52141486	50.96	5.2	51.3622	-179.2571
GOL	P	198401291614363	56.85	5.2	71.8835	-1.5914
GOL	P	198401301613510	57.36	4.4	75.4703	7.6667
GOL	P	19840117 332 80	57.73	5.1	-8.883	-71.3051
GOL	P	198401261930590	58.09	5.1	-12.2722	-76.9016
GOL	P	198401141334 64	58.62	4.8	-11.5795	-74.3015
GOL	P	19840125 717589	65.63	4.9	8.7444	-39.8998
GOL	P	19840125 659 04	66	4.9	8.6203	-39.5093
GOL	P	19840125 351451	66.05	5.1	8.6614	-39.4137
GOL	P	198401161227240	69.67	5.7	-30.0345	-112.2646
GOL	P	198401 42240417	70.96	6	45.3996	151.3144
GOL	P	198401 615 1344	71.79	5.3	-23.7739	-68.7914
GOL	P	198401 122 8121	72.1	5.4	-22.6582	-66.0139
GOL	P	19840125 935 58	77.53	5.3	42.2668	143.0713
GOL	P	198401171113418	82.58	5.6	36.5099	141.1398
GOL	P	198401241847570	84.07	4.9	-16.3865	-173.0189
GOL	P	198401 418 0 53	84.42	5	-15.6647	-174.24
GOL	P	198401 1 9 3401	87.13	6.4	33.6199	136.803
GOL	P	19840120 133248	88.03	5.2	50.6363	96.3999
GOL	P	198401221351513	88.32	5.3	-21.3032	-174.2573
GOL	P	19840120 353 34	88.94	5.3	-17.8164	-178.6029
GOL	P	198401171949582	92.61	5.4	-22.2384	-179.6396
GOL	P	198401191615155	92.66	5.8	-23.6792	-178.2983
GOL	P	19840123 734569	93.97	5.8	29.2822	130.438

35 records selected.

Figure Captions

Figure 1: Locations of seismic stations in the former Soviet Union. (a) Stations that report (or have previously reported) seismic phase data to the ISC. (b) Stations used for demonstration of SQL queries using a database created by programs written for this project.

Figure 2: (a) Epicenters of all events reported in the ISC Bulletin for the month of January 1986 ($1.3 \le m_b \le 6.2$). (b) Epicenters of all events reported in the ISC Bulletin for the month of January 1984 ($1.6 \le m_b \le 6.4$).

Figure 3: Epicenters of all events for which at least one phase was reported by station OBN during January 1986 ($4.2 \le m_b \le 5.9$).

Figure 4: Epicenters of all events for which at least one phase was reported by station YAK during January 1986 ($4.4 \le m_b \le 6.0$).

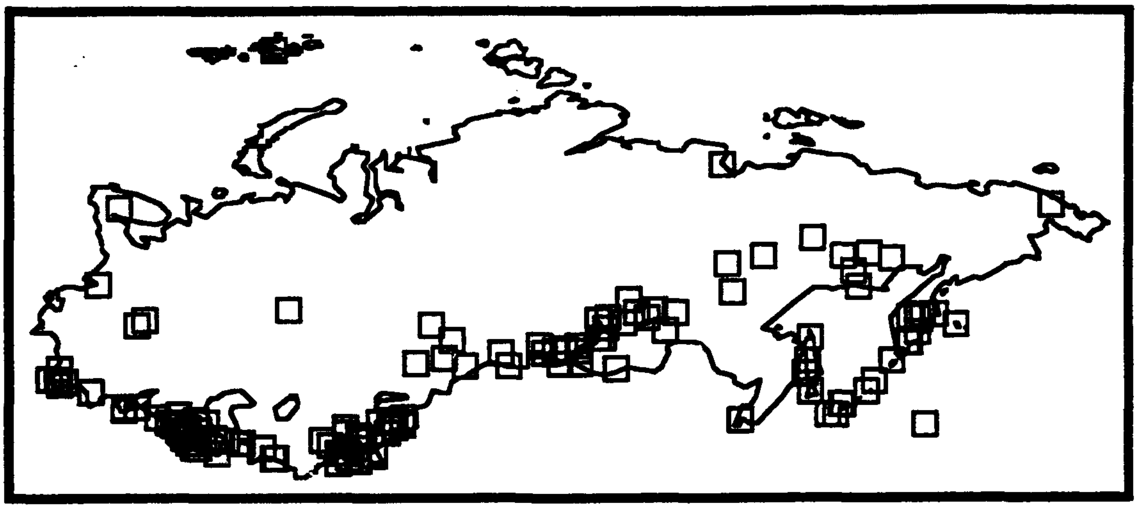
Figure 5: Epicenters of all events for which at least one phase was reported by station BLA during January 1986 ($4.8 \le m_b \le 5.7$).

Figure 6: Epicenters of all events for which at least one phase was reported by station GOL during January 1986 ($4.1 \le m_b \le 5.9$).

Figure 7: Epicenters of all events for which at least one phase was reported by station OBN during January 1984 ($0.0 \le m_b \le 6.4$).

Figure 8: (a) Epicenters of events for which there were P phases reported by OBN, but not NVS, during January 1984. (b) Epicenters of events for which there were P phases reported by NVS, but not OBN during January 1984.

(a)



(b)

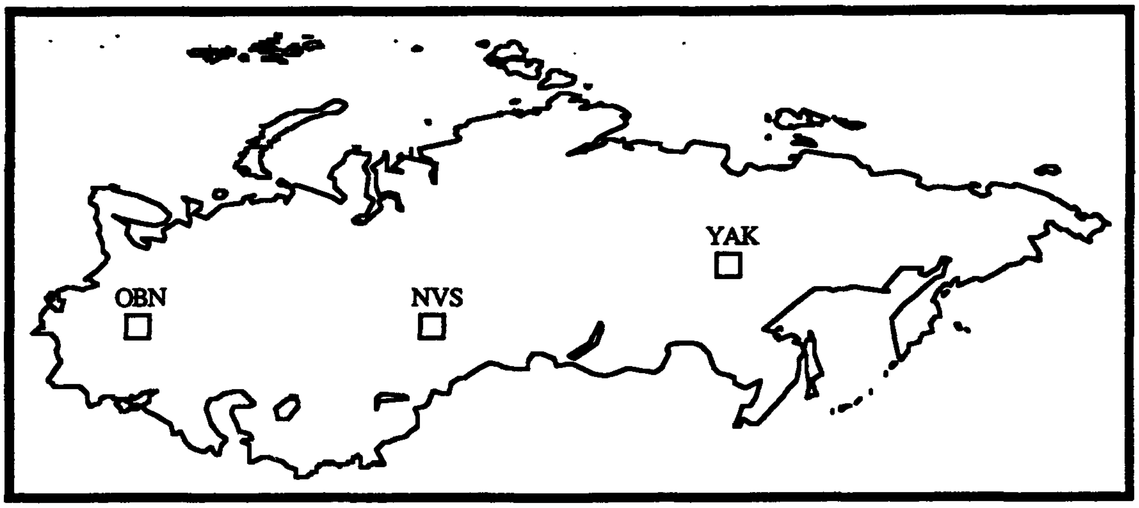
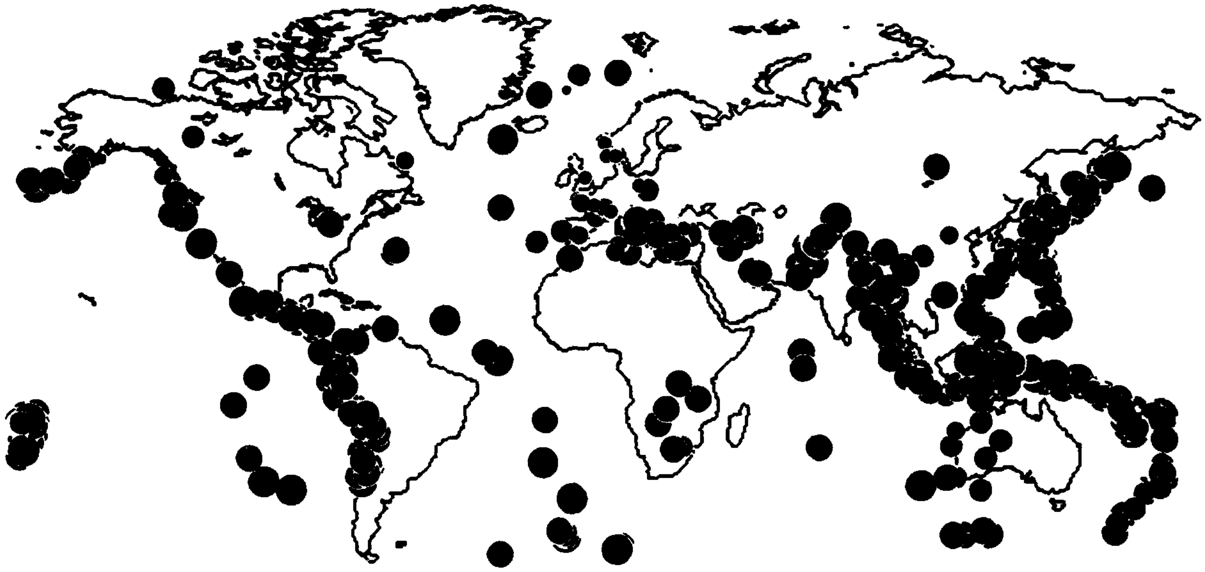
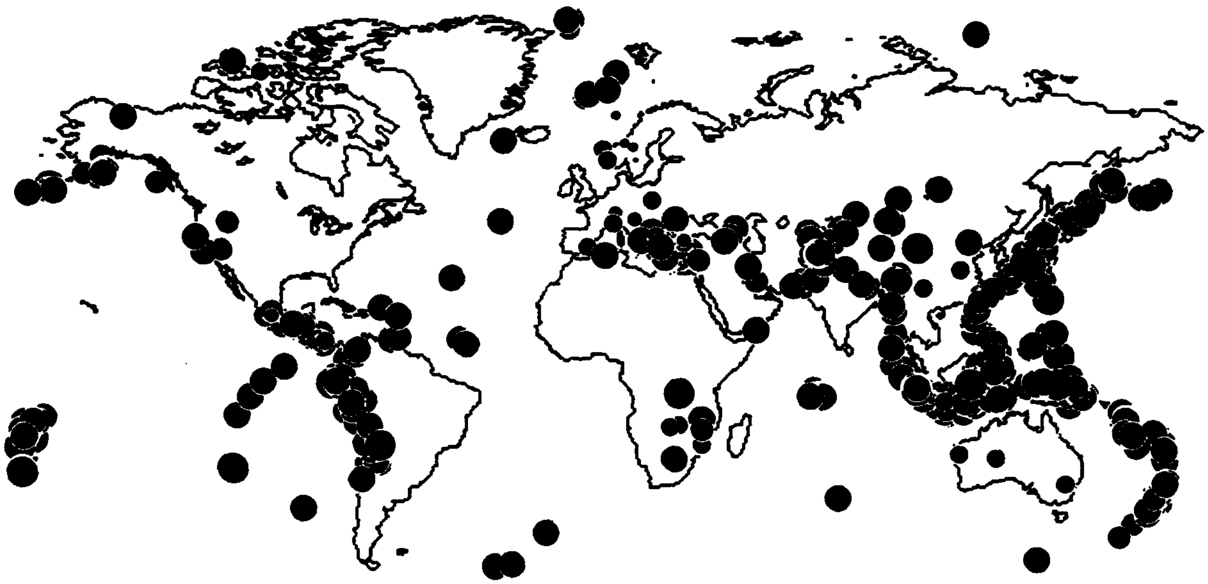


Figure 1



(a) January 1986 ($1.3 \leq m_b \leq 6.2$)



(b) January 1984 ($1.6 \leq m_b \leq 6.4$)

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

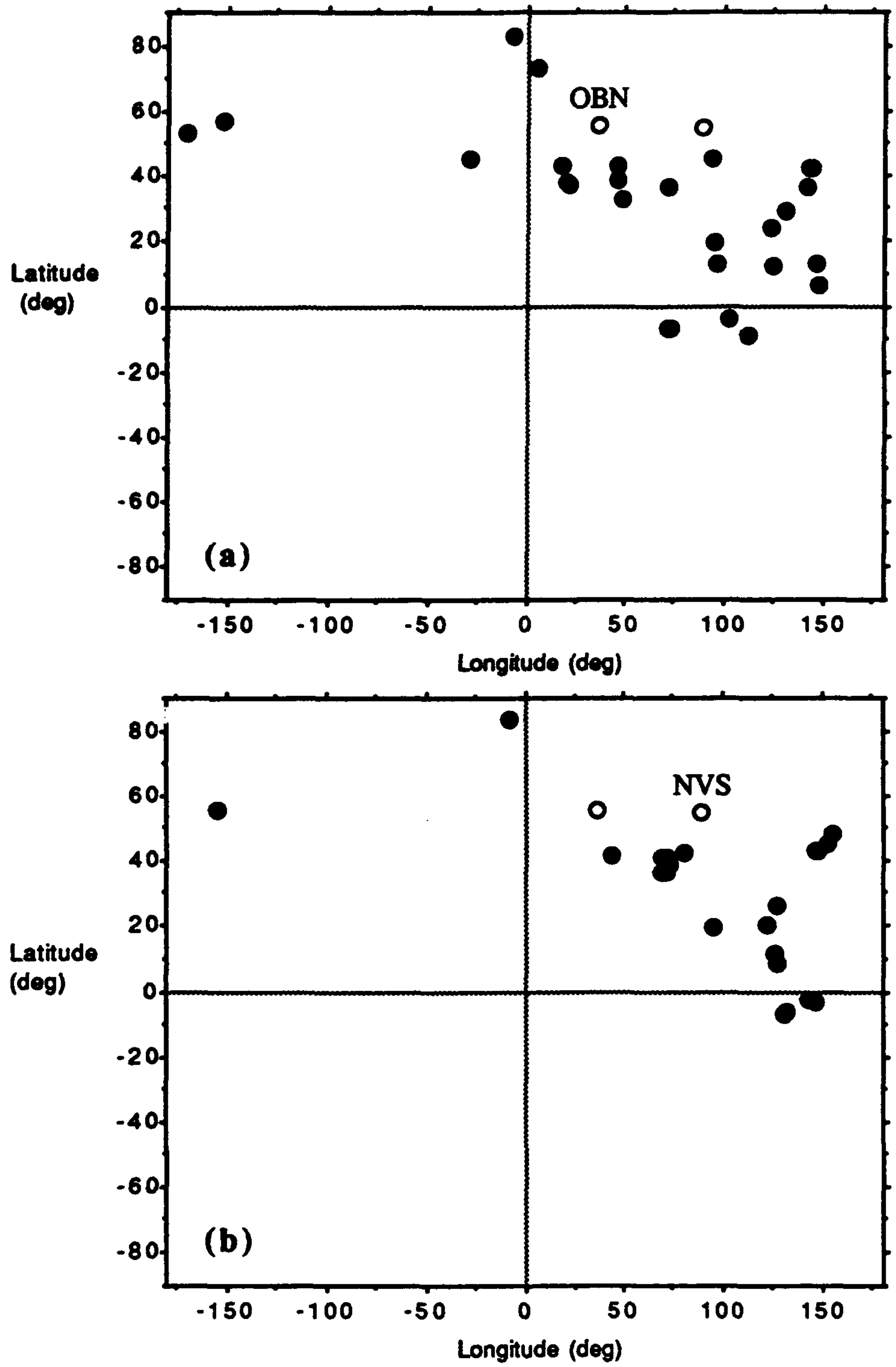

OBN
(a)
Latitude (deg)
Longitude (deg)
NVS
(b)
Latitude (deg)
Longitude (deg)

Figure 8

APPENDIX A

Program for Creating the Relation arrival.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>
#include <float.h>

#include "f_mot.c"
#include "mid_str.c"
#include "day.c"
#include "Time_Subs.c"

#define CHANID -1
#define CHAN "       -"
#define COMMID -1
#define DELTIM -1.0
#define AZIMUTH -1.0
#define DELAZ -1.0
#define SLOW -1.0
#define DELSLO -1.0
#define EMA -1.0
#define RECT -1.0
#define LOGAT -999.0
#define STYPE '-'
#define CLIP '-'
#define SNR -1.0

double timecon(char *timstr);
double dtoepoch(long date);
char *mid_str(char str[], int first, int length);
fmot(char fm[], char fmtn);

main()
{
  FILE *infile, *outfile, *info;
  char in_line[100], out_line[225], out1[200], out2[200], out3[200];
  char tmp2[2];
  int i, j, n, slength;
  char nxtrc, thsrc;

  int get_out;
  int arid, stassid;
  int mo, da, hr, mn;
  char s_yr[5], s_mo[3], s_da[3], s_hr[3], s_mn[3];
  long int jdate, yr;
  char stype, qual, fmtn, aut;
  char sta[6], iphase[9], fm[3], auth[16], lddate[20];
  char file_1[21], file_2[21];
  float per, sec;
  double ampl, amp2, amp, time;
  char s_per[8], s_sec[5], s_ampl[5], s_amp2[3], s_time[13];

  info = fopen("run_info","r");
  fgets(lddate,20,info);
```

```
    lddate[strlen(lddate)-1] = '\0';
  fgets(file_1,20,info);
    file_1[strlen(file_1)-1] = '\0';
  fgets(file_2,20,info);
    file_2[strlen(file_2)-1] = '\0';

  infile = fopen(file_1,"r");
  outfile = fopen(file_2,"w");

  arid = 1;
  get_out=0;
  nxtrc = '?';

    for (stassid=1; get_out!=1; stassid=stassid+1)
    {
      for (i=1; (nxtrc!='1' || get_out!=1); i=i+1)
      {
      fgets(in_line,100,infile);
      slength = strlen(in_line)-1;

      strcpy(tmp2,mid_str(in_line,slength,1));
      nxtrc = tmp2[0];
      if (nxtrc=='9') get_out=1;
      strcpy(tmp2,mid_str(in_line,1,1));
      thsrc = tmp2[0];

      if (i!=1)
    {
      switch(thsrc)
        {
        case '2':
          amp = -1.0;
          per = -1.0;
          strcpy(sta, mid_str(in_line,10,5));
          strcpy(s_yr, mid_str(in_line,2,4));
          yr  = atoi(s_yr);
          strcpy(s_mo, mid_str(in_line,6,2));
          mo  = atoi(s_mo);
          strcpy(s_da, mid_str(in_line,8,2));
          da  = atoi(s_da);
          strcpy(s_hr, mid_str(in_line,39,2));
          hr  = atoi(s_hr);
          strcpy(s_mn, mid_str(in_line,41,2));
          mn  = atoi(s_mn);
          strcpy(s_sec, mid_str(in_line,43,4));
          sec = atof(s_sec);
          sec = 0.01*sec;
          jdate = (1000*yr) + doy(mo, da, yr);
          sprintf(s_time, "%2d:%2d:%6.3f", hr, mn, sec);
          time = dtoepoch(jdate) + timecon(s_time);
          fmtn = *mid_str(in_line,38,1);
          qual = *mid_str(in_line,24,1);
          fmot(fm,fmtn);
```

```
     strcpy(iphase, mid_str(in_line,25,8));
     aut = *mid_str(in_line,37,1);
   switch(aut)
    {
    case 'I':
       strcpy(auth,"             ISC");
       break;
    case 'O':
       strcpy(auth,"        OPERATOR");
       break;
    default :
       strcpy(auth,"       ISC-FAISE");
    }
     break;

   case '3':
     strcpy(s_ampl, mid_str(in_line,7,4));
     ampl = 0.001*atof(s_ampl);
     strcpy(s_amp2, mid_str(in_line,11,2));
     amp2 = atof(s_amp2);
     amp = pow(10.0,(ampl+amp2));
     strcpy(s_per, mid_str(in_line,15,4));
     per = 0.01*atof(s_per);
     break;

   case '4':
     amp = -1.0;
     per = -1.0;
     strcpy(fm, "--");
     strcpy(iphase, mid_str(in_line,4,8));
     qual = *mid_str(in_line,3,1);
     aut = *mid_str(in_line,16,1);
   switch(aut)
    {
    case 'I':
       strcpy(auth,"             ISC");
       break;
    case 'O':
       strcpy(auth,"        OPERATOR");
       break;
    default :
       strcpy(auth,"       ISC-FAISE");
    }
     strcpy(s_yr, mid_str(in_line,17,4));
     yr  = atoi(s_yr);
     strcpy(s_mo, mid_str(in_line,21,2));
     mo  = atoi(s_mo);
     strcpy(s_da, mid_str(in_line,23,2));
     da  = atoi(s_da);
     strcpy(s_hr, mid_str(in_line,25,2));
     hr  = atoi(s_hr);
     strcpy(s_mn, mid_str(in_line,27,2));
     mn  = atoi(s_mn);
```

```
          strcpy(s_sec, mid_str(in_line,29,4));
          sec = atof(s_sec);
          sec = 0.01*sec;
          jdate = (1000*yr) + doy(mo, da, yr);
          sprintf(s_time, "%2d:%2d:%6.3f", hr, mn, sec);
          time = dtoepoch(jdate) + timecon(s_time);
          break;

        case '5':
          strcpy(s_ampl, mid_str(in_line,7,4));
          ampl = 0.001*atof(s_ampl);
          strcpy(s_amp2, mid_str(in_line,11,2));
          amp2 = atof(s_amp2);
          amp = pow(10.0,(ampl+amp2));
          strcpy(s_per, mid_str(in_line,15,4));
          per = 0.01*atof(s_per);
          break;
        }

      switch(nxtrc)
        {
        case '3':
          break;
        case '5':
          break;
        case '6':
          break;
        default :
          sprintf(out1,"%5s  %17.5f %8d %81d %8d %8d %8s %8s %1c ",
              sta, time, arid, jdate, stassid, CHANID, CHAN, iphase,
              STYPE);
          sprintf(out2,"%6.3f %7.2f %7.2f %7.2f %7.2f %7.2f %7.3f %10.1f",
              DELTIM, AZIMUTH, DELAZ, SLOW, DELSLO, EMA, RECT, amp);
          sprintf(out3," %7.2f %7.2f %1c %2s %10.2f %1c %15s %8d %17s",
              per, LOGAT, CLIP, fm, SNR, qual, auth, COMMID, lddate);

          sprintf(out_line,"%s%s%s\n",out1,out2,out3);
          fputs(out_line,outfile);

        arid = arid +1;
        }
    }
      if (nxtrc=='1' || get_out==1) break;
      }
    }

  fclose(infile); fclose(outfile), fclose(info);

  exit(0);
}
```

APPENDIX B

Program for Creating the Relation assoc.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>
#include <float.h>

#include "f_mot.c"
#include "mid_str.c"
#include "day.c"
#include "Time_Subs.c"

#define COMMID -1

char *mid_str(char str[], int first, int length);

main()
{
  FILE *infile, *outfile, *info;
  char in_line[100], out_line[225], out1[200], out2[200], out3[200];
  char tmp2[2];
  int i, slength;
  char nxtrc, thsrc;
  char file_1[21], file_2[21];

  int get_out;
  int arid, orid;
  char timedef, azdef, slodef;
  char sta[6], phase[9], vmodel[16];
  float belief, delta, seaz, esaz, timeres, azres, slores, emares, wgt;
  char s_delta[9], s_esaz[8], s_timeres[9], lddate[20];

  info = fopen("run_info","r");
  fgets(lddate,20,info);
    lddate[strlen(lddate)-1] = '\0';
  fgets(file_1,20,info);
    file_1[strlen(file_1)-1] = '\0';
  fgets(file_2,20,info);
    file_2[strlen(file_2)-1] = '\0';

  infile = fopen(file_1,"r");
  outfile = fopen(file_2,"w");

  arid = 1;
  get_out=0;
  nxtrc = '?';

    for (orid=1; get_out!=1; orid=orid+1)
    {
      for (i=1; (nxtrc!='1' || get_out!=1); i=i+1)
      {
      fgets(in_line,100,infile);
      slength = strlen(in_line)-1;
```

```
        strcpy(tmp2,mid_str(in_line,slength,1));
        nxtrc = tmp2[0];
        if (nxtrc=='9') get_out=1;
        strcpy(tmp2,mid_str(in_line,1,1));
        thsrc = tmp2[0];

        if (i!=1)
      {
        switch(thsrc)
          {
          case '2':
            strcpy(sta, mid_str(in_line,10,5));
            strcpy(phase, mid_str(in_line,25,8));
            belief = -1.0;
            strcpy(s_delta, mid_str(in_line,15,5));
            delta = atof(s_delta);
            delta = 0.01*delta;
            seaz = -999.0;
            strcpy(s_esaz, mid_str(in_line,20,3));
            esaz = atof(s_esaz);
            strcpy(s_timeres, mid_str(in_line,33,4));
            timeres = atof(s_timeres);
            timeres = 0.1*timeres;
            timedef = '-';
            azres = -999.0;
            azdef = '-';
            slores = -99999.0;
            slodef = '-';
            emares = -999.0;
            wgt = -1.0;
            strcpy(vmodel, "-");
            break;

          case '4':
            strcpy(phase, mid_str(in_line,4,8));
            belief = -1.0;
            strcpy(s_timeres, mid_str(in_line,12,4));
            timeres = atof(s_timeres);
            timeres = 0.1*timeres;
            timedef = '-';
            break;
          }

          if (thsrc=='2' || thsrc=='4')
            {
            sprintf(out1,"%8d %8d %5s  %8s %4.1f %8.3f %7.2f ",
                arid, orid, sta, phase, belief, delta, seaz);
            sprintf(out2,"%7.2f %8.3f %1c %7.1f %1c %7.0f %1c",
                esaz, timeres, timedef, azres, azdef, slores, slodef);
            sprintf(out3," %7.1f %6.3f %15s %8d %17s",
                emares, wgt, vmodel, COMMID, lddate);

            sprintf(out_line,"%s%s%s\n",out1,out2,out3);
```

```
            fputs(out_line,outfile);

            arid = arid+1;
            }
      }
        if (nxtrc=='1' || get_out==1) break;
        }
      }

   fclose(infile); fclose(outfile), fclose(info);

   exit(0);
}
```

APPENDIX C

Program for Creating the Relation **event.**

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define AUTH "      ISC-FAISE"
#define COMMID -1

main()
{
   FILE *infile, *outfile, *info;
   char lddate[20], in_line[100], out_line[100];
   int i, j, n, evid, prefor, slength, get_out;
   char nxtrc, thsrc, evname[16];
   char file_1[21], file_2[21];

  info = fopen("run_i  o","r");
  fgets(lddate,20,info);
    lddate[strlen(lddate)-1] = '\0';
  fgets(file_1,20,info);
    file_1[strlen(file_1)-1] = '\0';
  fgets(file_2,20,info);
    file_2[strlen(file_2)-1] = '\0';

  infile = fopen(file_1,"r");
  outfile = fopen(file_2,"w");

   n=0; while (nxtrc!='9')
     {
     n=n+1;
     evid = n; prefor = n;

     for (i=1; i<=100; i++)
     {
     fgets(in_line,100,infile);
     slength = strlen(in_line)-1;
     nxtrc = in_line[slength-1];
     if (nxtrc=='9') exit(0);
     thsrc = in_line[0];

     if (i==1)
        {
        for (j=0; j<=14; j++) evname[j]=in_line[4+j]; evname[15]='\0';

        sprintf(out_line,"%8d %15s %8d %15s %8d %17s\n",
            evid, evname, prefor, AUTH, COMMID, lddate);
        fputs(out_line,outfile);
        }
     if (nxtrc=='1') break;
     }
     }

   fclose(infile); fclose(outfile), fclose(info);
```

```
   exit(0);
}
```

APPENDIX D

Program for Creating the Relation **origin**.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>
#include <float.h>

#include <f_mot.c>
#include <julian.c>
#include <time_sec.c>
#include <midstr.c>

#define AUTH "      ISC-FAISE"
#define COMMID -1

double dtoepoch(long date);
double timecon(char *timstr);
char *mid_str(char str[], int first, int length);
fmot(char fm[], char fmtn);

main()
{
  FILE *infile, *outfile, *info;
  char in_line[100], out_line[250], out1[200], out2[200], out3[200];
  char tmp2[2];
  int i, slength;
  char nxtrc, thsrc;

  int get_out;
  int orid, evid, nass, ndef, ndp, grn, srn, mbid, msid, mlid;
  char s_nass[5], s_ndef[5], s_ndp[5], s_grn[9], s_srn[8], s_mbid[9],
       s_msid[9], s_mlid[9];
  int mo, da, hr, mn;
  char s_yr[5], s_mo[3], s_da[3], s_hr[3], s_mn[3];
  char dtype;
  char lddate[20], etype[8], algorithm[16], s_time[13];
  float lat, lon, depth, depdp, mb, ms, ml, sec;
  char s_lat[8], s_lon[9], s_depth[5], s_mb[3], s_ms[3], s_sec[5];
  long int jdate, yr;
  double time;
  char file_1[21], file_2[21];

  info = fopen("run_info","r");
  fgets(lddate,20,info);
    lddate[strlen(lddate)-1] = '\0';
  fgets(file_1,20,info);
    file_1[strlen(file_1)-1] = '\0';
  fgets(file_2,20,info);
    file_2[strlen(file_2)-1] = '\0';

  infile = fopen(file_1,"r");
  outfile = fopen(file_2,"w");

  get_out=0;
```

```
 nxtrc = '?';

   for (orid=1; get_out!=1; orid=orid+1)
   {
   evid = orid;
     for (i=1; (nxtrc!='1' || get_out!=1); i=i+1)
     {
     fgets(in_line,100,infile);
     slength = strlen(in_line)-1;

     strcpy(tmp2,mid_str(in_line,slength,1));
     nxtrc = tmp2[0];
     if (nxtrc=='9') get_out=1;
     strcpy(tmp2,mid_str(in_line,1,1));
     thsrc = tmp2[0];

     if (i==1)
   {
   strcpy(s_lat, mid_str(in_line,23,7));
   lat = atof(s_lat);
   lat = 0.0001*lat;
   strcpy(s_lon, mid_str(in_line,32,8));
   lon = atof(s_lon);
   lon = 0.0001*lon;
   strcpy(s_depth, mid_str(in_line,42,4));
   depth = atof(s_depth);
   depth = 0.1*depth;
   strcpy(s_yr, mid_str(in_line,5,4));
   yr  = atoi(s_yr);
   strcpy(s_mo, mid_str(in_line,9,2));
   mo  = atoi(s_mo);
   strcpy(s_da, mid_str(in_line,11,2));
   da  = atoi(s_da);
   strcpy(s_hr, mid_str(in_line,13,2));
   hr  = atoi(s_hr);
   strcpy(s_mn, mid_str(in_line,15,2));
   mn  = atoi(s_mn);
   strcpy(s_sec, mid_str(in_line,17,4));
   sec = atof(s_sec);
   sec = 0.01*sec;
   jdate = (1000*yr) + doy(mo, da, yr);
   sprintf(s_time, "%2d:%2d:%6.3f", hr, mn, sec);
   time = dtoepoch(jdate) + timecon(s_time);
   strcpy(s_nass, mid_str(in_line,58,4));
   nass = atoi(s_nass);
   ndef = -1;
   ndp = -1;
   grn = -1;
   srn = -1;
   strcpy(etype, "-");
   depdp = -999.0;
   dtype = '-';
   strcpy(s_mb, mid_str(in_line,48,2));
```

```
    mb = atof(s_mb);
    mb = 0.1*mb;
    mbid = -1;
    strcpy(s_ms, mid_str(in_line,53,2));
    ms = atof(s_ms);
    ms = 0.1*ms;
    msid = -1;
    ml = -999.0;
    mlid = -1;
    strcpy(algorithm, " ");

    sprintf(out1,"%9.4f %9.4f %9.4f %17.5f %8d %8d %8ld %4d",
        lat, lon, depth, time, orid, evid, jdate, nass);
    sprintf(out2," %4d %4d %8d %8d %7s %9.4f %1c %7.2f %8d",
        ndef, ndp, grn, srn, etype, depdp, dtype, mb, mbid);
    sprintf(out3," %7.2f %8d %7.2f %8d %15s %15s %8d %17s",
        ms, msid, ml, mlid, algorithm, AUTH, COMMID, lddate);

    sprintf(out_line,"%s%s%s\n",out1,out2,out3);
    fputs(out_line,outfile);

    }
      if (nxtrc=='1' || get_out==1) break;
      }
    }

   fclose(infile); fclose(outfile), fclose(info);

   exit(0);
}
```

APPENDIX E

Functions and Input File Used by
Programs Listed in Appendices A-D

```
fmot(char fm[], char fmtn)
{
   switch(fmtn)
   {
     case '+' :
    fm[0] = 'c'; fm[1] = '.';
    break;
     case '-' :
    fm[0] = 'd'; fm[1] = '.';
    break;
     case '1' :
    fm[0] = '.'; fm[1] = 'u';
    break;
     case '2' :
    fm[0] = '.'; fm[1] = 'r';
    break;
     case 'A' :
    fm[0] = 'c'; fm[1] = 'u';
    break;
     case 'B' :
    fm[0] = 'c'; fm[1] = 'r';
    break;
     case 'C' :
    fm[0] = 'C'; fm[1] = 'C';
    break;
     case 'D' :
    fm[0] = 'D'; fm[1] = 'D';
    break;
     case 'J' :
    fm[0] = 'd'; fm[1] = 'u';
    break;
     case 'K' :
    fm[0] = 'd'; fm[1] = 'r';
    break;

     default :
    fm[0] = '-'; fm[1] = '-';
   }
   fm[2] = '\0';
}
```

```
char *mid_str(char str[], int first, int length)
{
  char mid[100];
  int i, f, l;

  f = first-1;
  l = length-1;

  for (i=0; i<=l; i=i+1) mid[i]=str[f+i];
  mid[length]='\0';

  return mid;
}
```

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Prof. Thomas Ahrens
Seismological Lab, 252-21
Division of Geological & Planetary Sciences
California Institute of Technology
Pasadena, CA 91125

Prof. Keiiti Aki
Center for Earth Sciences
University of Southern California
University Park
Los Angeles, CA 90089-0741

Prof. Shelton Alexander
Geosciences Department
403 Deike Building
The Pennsylvania State University
University Park, PA 16802

Prof. Charles B. Archambeau
CIRES
University of Colorado
Boulder, CO 80309

Dr. Thomas C. Bache, Jr.
Science Applications Int'l Corp.
10260 Campus Point Drive
San Diego, CA 92121 (2 copies)

Prof. Muawia Barazangi
Institute for the Study of the Continent
Cornell University
Ithaca, NY 14853

Dr. Jeff Barker
Department of Geological Sciences
State University of New York
at Binghamton
Vestal, NY 13901

Dr. Douglas R. Baumgardt
ENSCO, Inc
5400 Port Royal Road
Springfield, VA 22151-2388

Dr. Susan Beck
Department of Geosciences
Building #77
University of Arizona
Tuscon, AZ 85721

Dr. T.J. Bennett
S-CUBED
A Division of Maxwell Laboratories
11800 Sunrise Valley Drive, Suite 1212
Reston, VA 22091

Dr. Robert Blandford
AFTAC/TT, Center for Seismic Studies
1300 North 17th Street
Suite 1450
Arlington, VA 22209-2308

Dr. Stephen Bratt
ARPA/NMRO
3701 North Fairfax Drive
Arlington, VA 22203-1714

Dr. Lawrence Burdick
IGPP, A-025
Scripps Institute of Oceanography
University of California, San Diego
La Jolla, CA 92093

Dr. Robert Burridge
Schlumberger-Doll Research Center
Old Quarry Road
Ridgefield, CT 06877

Dr. Jerry Carter
Center for Seismic Studies
1300 North 17th Street
Suite 1450
Arlington, VA 22209-2308

Dr. Eric Chael
Division 9241
Sandia Laboratory
Albuquerque, NM 87185

Dr. Martin Chapman
Department of Geological Sciences
Virginia Polytechnical Institute
21044 Derring Hall
Blacksburg, VA 24061

Prof. Vernon F. Cormier
Department of Geology & Geophysics
U-45, Room 207
University of Connecticut
Storrs, CT 06268

Prof. Steven Day
Department of Geological Sciences
San Diego State University
San Diego, CA 92182

Marvin Denny
U.S. Department of Energy
Office of Arms Control
Washington, DC 20585

Dr. Zoltan Der
ENSCO, Inc.
5400 Port Royal Road
Springfield, VA 22151-2388

Prof. Adam Dziewonski
Hoffman Laboratory, Harvard University
Dept. of Earth Atmos. & Planetary Sciences
20 Oxford Street
Cambridge, MA 02138

Prof. John Ebel
Department of Geology & Geophysics
Boston College
Chestnut Hill, MA 02167

Eric Fielding
SNEE Hall
INSTOC
Cornell University
Ithaca, NY 14853

Dr. Mark D. Fisk
Mission Research Corporation
735 State Street
P.O. Drawer 719
Santa Barbara, CA 93102

Prof Stanley Flatte
Applied Sciences Building
University of California, Santa Cruz
Santa Cruz, CA 95064

Dr. John Foley
NER-Geo Sciences
1100 Crown Colony Drive
Quincy, MA 02169

Prof. Donald Forsyth
Department of Geological Sciences
Brown University
Providence, RI 02912

Dr. Art Frankel
U.S. Geological Survey
922 National Center
Reston, VA 22092

Dr. Cliff Frolich
Institute of Geophysics
8701 North Mopac
Austin, TX 78759

Dr. Holly Given
IGPP, A-025
Scripps Institute of Oceanography
University of California, San Diego
La Jolla, CA 92093

Dr. Jeffrey W. Given
SAIC
10260 Campus Point Drive
San Diego, CA 92121

Dr. Dale Glover
Defense Intelligence Agency
ATTN: ODT-1B
Washington, DC 20301

Dan N. Hagedon
Pacific Northwest Laboratories
Battelle Boulevard
Richland, WA 99352

Dr. James Hannon
Lawrence Livermore National Laboratory
P.O. Box 808
L-205
Livermore, CA 94550

Prof. David G. Harkrider
Seismological Laboratory
Division of Geological & Planetary Sciences
California Institute of Technology
Pasadena, CA 91125

Prof. Danny Harvey
CIRES
University of Colorado
Boulder, CO 80309

Prof. Donald V. Helmberger
Seismological Laboratory
Division of Geological & Planetary Sciences
California Institute of Technology
Pasadena, CA 91125

Prof. Eugene Herrin
Institute for the Study of Earth and Man
Geophysical Laboratory
Southern Methodist University
Dallas, TX 75275

Prof. Robert B. Herrmann
Department of Earth & Atmospheric Sciences
St. Louis University
St. Louis, MO 63156

Prof. Lane R. Johnson
Seismographic Station
University of California
Berkeley, CA 94720

Prof. Thomas H. Jordan
Department of Earth, Atmospheric & Planetary Sciences
Massachusetts Institute of Technology
Cambridge, MA 02139

Prof. Alan Kafka
Department of Geology & Geophysics
Boston College
Chestnut Hill, MA 02167

Robert C. Kemerait
ENSCO, Inc.
445 Pineda Court
Melbourne, FL 32940

Dr. Karl Koch
Institute for the Study of Earth and Man
Geophysical Laboratory
Southern Methodist University
Dallas, Tx 75275

Dr. Max Koontz
U.S. Dept. of Energy/DP 5
Forrestal Building
1000 Independence Avenue
Washington, DC 20585

Dr. Richard LaCoss
MIT Lincoln Laboratory, M-200B
P.O. Box 73
Lexington, MA 02173-0073

Dr. Fred K. Lamb
University of Illinois at Urbana-Champaign
Department of Physics
1110 West Green Street
Urbana, IL 61801

Prof. Charles A. Langston
Geosciences Department
403 Deike Building
The Pennsylvania State University
University Park, PA 16802

Jim Lawson, Chief Geophysicist
Oklahoma Geological Survey
Oklahoma Geophysical Observatory
P.O. Box 8
Leonard, OK 74043-0008

Prof. Thorne Lay
Institute of Tectonics
Earth Science Board
University of California, Santa Cruz
Santa Cruz, CA 95064

Dr. William Leith
U.S. Geological Survey
Mail Stop 928
Reston, VA 22092

Mr. James F. Lewkowicz
Phillips Laboratory/GPEH
29 Randolph Road
Hanscom AFB, MA 01731-3010(2 copies)

Mr. Alfred Lieberman
ACDA/VI-OA State Department Building
Room 5726
320-21st Street, NW
Washington, DC 20451

Prof. L. Timothy Long
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, GA 30332

Dr. Randolph Martin, III
New England Research, Inc.
76 Olcott Drive
White River Junction, VT 05001

Dr. Robert Masse
Denver Federal Building
Box 25046, Mail Stop 967
Denver, CO 80225

Dr. Gary McCartor
Department of Physics
Southern Methodist University
Dallas, TX 75275

Prof. Thomas V. McEvilly
Seismographic Station
University of California
Berkeley, CA 94720

Dr. Art McGarr
U.S. Geological Survey
Mail Stop 977
U.S. Geological Survey
Menlo Park, CA 94025

Dr. Keith L. McLaughlin
S-CUBED
A Division of Maxwell Laboratory
P.O. Box 1620
La Jolla, CA 92038-1620

Stephen Miller & Dr. Alexander Florence
SRI International
333 Ravenswood Avenue
Box AF 116
Menlo Park, CA 94025-3493

Prof. Bernard Minster
IGPP, A-025
Scripps Institute of Oceanography
University of California, San Diego
La Jolla, CA 92093

Prof. Brian J. Mitchell
Department of Earth & Atmospheric Sciences
St. Louis University
St. Louis, MO 63156

Mr. Jack Murphy
S-CUBED
A Division of Maxwell Laboratory
11800 Sunrise Valley Drive, Suite 1212
Reston, VA 22091 (2 Copies)

Dr. Keith K. Nakanishi
Lawrence Livermore National Laboratory
L-025
P.O. Box 808
Livermore, CA 94550

Prof. John A. Orcutt
IGPP, A-025
Scripps Institute of Oceanography
University of California, San Diego
La Jolla, CA 92093

Prof. Jeffrey Park
Kline Geology Laboratory
P.O. Box 6666
New Haven, CT 06511-8130

Dr. Howard Patton
Lawrence Livermore National Laboratory
L-025
P.O. Box 808
Livermore, CA 94550

Dr. Frank Pilotte
HQ AFTAC/TT
1030 South Highway A1A
Patrick AFB, FL 32925-3002

Dr. Jay J. Pulli
Radix Systems, Inc.
201 Perry Parkway
Gaithersburg, MD 20877

Dr. Robert Reinke
ATTN: FCTVTD
Field Command
Defense Nuclear Agency
Kirtland AFB, NM 87115

Prof. Paul G. Richards
Lamont-Doherty Geological Observatory
of Columbia University
Palisades, NY 10964

Mr. Wilmer Rivers
Teledyne Geotech
314 Montgomery Street
Alexandria, VA 22314

Dr. Alan S. Ryall, Jr.
ARPA/NMRO
3701 North Fairfax Drive
Arlington, VA 22203-1714

Dr. Richard Sailor
TASC, Inc.
55 Walkers Brook Drive
Reading, MA 01867

Prof. Charles G. Sammis
Center for Earth Sciences
University of Southern California
University Park
Los Angeles, CA 90089-0741

Prof. Christopher H. Scholz
Lamont-Doherty Geological Observatory
of Columbia University
Palisades, NY 10964

Dr. Susan Schwartz
Institute of Tectonics
1156 High Street
Santa Cruz, CA 95064

Secretary of the Air Force
(SAFRD)
Washington, DC 20330

Office of the Secretary of Defense
DDR&E
Washington, DC 20330

Thomas J. Sereno, Jr.
Science Application Int'l Corp.
10260 Campus Point Drive
San Diego, CA 92121

Dr. Michael Shore
Defense Nuclear Agency/SPSS
6801 Telegraph Road
Alexandria, VA 22310

Dr. Robert Shumway
University of California Davis
Division of Statistics
Davis, CA 95616

Dr. Matthew Sibol
Virginia Tech
Seismological Observatory
4044 Derring Hall
Blacksburg, VA 24061-0420

Prof. David G. Simpson
IRIS, Inc.
1616 North Fort Myer Drive
Suite 1050
Arlington, VA 22209

Donald L. Springer
Lawrence Livermore National Laboratory
L-025
P.O. Box 808
Livermore, CA 94550

Dr. Jeffrey Stevens
S-CUBED
A Division of Maxwell Laboratory
P.O. Box 1620
La Jolla, CA 92038-1620

Lt. Col. Jim Stobie
ATTN: AFOSR/NL
110 Duncan Avenue
Bolling AFB
Washington, DC 20332-0001

Prof. Brian Stump
Institute for the Study of Earth & Man
Geophysical Laboratory
Southern Methodist University
Dallas, TX 75275

Prof. Jeremiah Sullivan
University of Illinois at Urbana-Champaign
Department of Physics
1110 West Green Street
Urbana, IL 61801

Prof. L. Sykes
Lamont-Doherty Geological Observatory
of Columbia University
Palisades, NY 10964

Dr. David Taylor
ENSCO, Inc.
445 Pineda Court
Melbourne, FL 32940

Dr. Steven R. Taylor
Los Alamos National Laboratory
P.O. Box 1663
Mail Stop C335
Los Alamos, NM 87545

Prof. Clifford Thurber
University of Wisconsin-Madison
Department of Geology & Geophysics
1215 West Dayton Street
Madison, WS 53706

Prof. M. Nafi Toksoz
Earth Resources Lab
Massachusetts Institute of Technology
42 Carleton Street
Cambridge, MA 02142

Dr. Larry Turnbull
CIA-OSWR/NED
Washington, DC 20505

Dr. Gregory van der Vink
IRIS, Inc.
1616 North Fort Myer Drive
Suite 1050
Arlington, VA 22209

Dr. Karl Veith
EG&G
5211 Auth Road
Suite 240
Suitland, MD 20746

Prof. Terry C. Wallace
Department of Geosciences
Building #77
University of Arizona
Tuscon, AZ 85721

Dr. Thomas Weaver
Los Alamos National Laboratory
P.O. Box 1663
Mail Stop C335
Los Alamos, NM 87545

Dr. William Wortman
Mission Research Corporation
8560 Cinderbed Road
Suite 700
Newington, VA 22122

Prof. Francis T. Wu
Department of Geological Sciences
State University of New York
at Binghamton
Vestal, NY 13901

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ATTN: GPE
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Hanscom AFB, MA 01731-3010

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ATTN: TSML
5 Wright Street
Hanscom AFB, MA 01731-3004

Phillips Laboratory
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Kirtland, NM 87117-5776 (2 copies)

Dr. Michel Bouchon
I.R.I.G.M.-B.P. 68
38402 St. Martin D'Heres
Cedex, FRANCE

Dr. Michel Campillo
Observatoire de Grenoble
I.R.I.G.M.-B.P. 53
38041 Grenoble, FRANCE

Dr. Kin Yip Chun
Geophysics Division
Physics Department
University of Toronto
Ontario, CANADA

Prof. Hans-Peter Harjes
Institute for Geophysic
Ruhr University/Bochum
P.O. Box 102148
4630 Bochum 1, GERMANY

Prof. Eystein Husebye
NTNF/NORSAR
P.O. Box 51
N-2007 Kjeller, NORWAY

David Jepsen
Acting Head, Nuclear Monitoring Section
Bureau of Mineral Resources
Geology and Geophysics
G.P.O. Box 378, Canberra, AUSTRALIA

Ms. Eva Johannisson
Senior Research Officer
FOA
S-172 90 Sundbyberg, SWEDEN

Dr. Peter Marshall
Procurement Executive
Ministry of Defense
Blacknest, Brimpton
Reading FG7-FRS, UNITED KINGDOM

Dr. Bernard Massinon, Dr. Pierre Mechler
Societe Radiomana
27 rue Claude Bernard
75005 Paris, FRANCE (2 Copies)

Dr. Svein Mykkeltveit
NTNT/NORSAR
P.O. Box 51
N-2007 Kjeller, NORWAY (3 Copies)

Prof. Keith Priestley
University of Cambridge
Bullard Labs, Dept. of Earth Sciences
Madingley Rise, Madingley Road
Cambridge CB3 OEZ, ENGLAND

Dr. Jorg Schlittenhardt
Federal Institute for Geosciences & Nat'l Res.
Postfach 510153
D-30631 Hannover, GERMANY

Dr. Johannes Schweitzer
Institute of Geophysics
Ruhr University/Bochum
P.O. Box 1102148
4360 Bochum 1, GERMANY

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VERTIC
Carrara House
20 Embankment Place
London WC2N 6NN, ENGLAND